Growth performance of genetically modified tilapia (*Oreochromis niloticus*) cultured in concrete pond

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Abstract

The semi-intensive culture of tilapia is particularly ideal in developing countries because it provides a wide variety of options in management and capital investments. A total of 1000 Genetically Modified Tilapia (GMT), Nile tilapia (*Oreochromis niloticus*) fry were stocked and reared in a concrete pond with a dimension of 1×1×5m for six months. The mean values of the water quality parameters during the rearing/experimental period were pH 7.25±0.31; temperature 25.85°C±2.98°C; dissolve oxygen (DO) 4.166mg/L±0.55mg/L; Nitrate 9.44±1.91; Nitrite 40.99±1.38 and Ammonia 0.01. The fish specimens were fed twice a day (morning and evening) with coppens at three percent of their body weight and the parameters recorded were, 11.48±5.48 MWG; 177.6±122.9%MWG, 204.6±19.2DRF; 1.44±0.14WRF; 6.14±0.57, MRF; 0.67±0.38F CR; 0.002±0.001 SGR, and 0.006±0.002 GEFC. The data indicated that mean weight gained (MWG) of *Oreochromis niloticus* increased gradually reaching its maximum. FCR values gradually decreased throughout the experiment which indicates that the lower the FCR the better it is for fish growth. The survival rates of the fish specimens during the experiment were 100 percent at different optimum temperatures, there was an increased trend in the growth with an increase in dietary protein level. It has been clearly verified from this experiment that all super male of *Oreochromis niloticus* grew better also in concrete pond. This result will promote the use of Genetically Modified Tilapia (GMT) in fish farming, because more weight are achieved and this will help to meet the goal of controlling tilapia prolific reproduction.

Keywords: *Oreochromis niloticus*, GMT, growth performance, concrete pond

Introduction

Fish farming which is also part of Aquaculture is ascending at a rate of 2.99% with 3.9% increase in geographical distribution. In Nigeria, fish farming as an enterprise is increasing in magnitude every day, farmers need to be equipped with information such as ideas on nutritional facts, social amenities facilities, geographical location e.g. land and the type of soil to be used, also topography of the land so that the production can be of a

greater profit to meet local needs where necessary, in order to venture into global market (Ayoola, 2010). Fish plays a vital role in our daily lives as one of the major sources of animal protein. Medically adults are to consume more of fish protein than beef for health related reasons.

Fish farming though labour intensive ensures quicker economical returns than animal husbandry, an average farmer can make use of limited space for the rearing of fishes but needs wider space for the rearing

of other sources of animal protein such as pigs, cows, and chickens due to its cheaper facilities used in investing it, for instance an average farmer can make use of plastic tanks for the rearing of fishes but plastic tanks cannot be used for the rearing of other sources of animal protein e.g. pigs, cows, and chicken (Ayoola, 2010). Fish is a more efficient protein and mineral sources in Nigeria providing essential amino acids such as Thiamine, Riboflavin, vitamin A, vitamin D, phosphorus, calcium and iron. They are high in polyunsaturated fatty acids which regulate the blood cholesterol (Areola, 2008). According to FAO (2003), fish farming conditions has shown an increase of 9.2% in the production from 1970 to 2002, in comparison to the only 1.4% of the extractive fishing and 2.8% terrestrial animal's production. China remains as the biggest producer, with 71% of the volume and about 50% in terms of the value. Nigeria is a large fish consuming nation with a total consumption at more than 1, 2 million metric tonnes (MT) out of which local production is 620,000MT and fish imports are 740,000MT. Nigeria spends an estimated N125.38 billion importing fish every year.

Due to this explosion in the aquaculture, the fish's worldwide production also significantly increased in the last 12 years. The production increased from 8.6 million tons to 24.4 million tons in 2001 (Borghetti *et al.*, 2003).

Tilapias are unique as one of the utmost cultured species all over the world, being the third species for global production with 5.7%, trailed by other cyprinid fish species that represent 87.2% of the over-all amount of the fishes reared in the world, and the salmonid fish species that tally to about 7.2% of the fish production (Borghetti *et al.*, 2003). The global production of tilapia in most recent years was increased by the

fast development of the *Oreochromis niloticus* specie, raised in Egypt, China, Thailand, Philippines and lastly Indonesia. During the years 1984 to 1995, Tilapia culture showed a substantial growth from 38%, that is, 198,000 tons to 57% (659,000 tons) (Fitzsimmons, 2000). According to BFAR. (2005), Tilapia is among the third common species cultured in Philippine making production increase in aquaculture. Basically, Nile tilapias mostly originated from Africa and Middle East, and also seems to be practice in tropical and sub-tropical countries. Nile tilapia (*Oreochromis niloticus*) is the core species cultivated in ponds, cages and pens. The Food and Agriculture Organization of the United Nations (FAO, 2000) states that the production of cultured tilapia has an annual rate of 12% which seems to encourage fish farmers globally. Despite these good characteristics, the major setback to tilapia production is the ability to breed early and overpopulate a cultured farm, under optimal and good condition, some species of tilapia precisely the females may produce from 100 to few thousands every 4 weeks to 7 weeks. (Balarin and Haller, 1983). Nile tilapia (*Oreochromis niloticus*) is omnivorous. It feeds basically on planktons such as faunas (benthic), aquatic plants, small molluscs or invertebrate and detritus. *Oreochromis niloticus* can sieve feed but it frequently grazes the surface of periphyton mats (FAO, 2006; FAO, 2007). Overpopulation caused by tilapias leads to overcrowding and also competition for food (Balarin and Haller 1983). Solution to this problem is to consider monosex farming, cultured of male tilapia precisely is the best solution, moreover male tilapia grows faster than females (Mohamed *et al.*, 2007).

Tilapias (Family Cichlidae) are mouth brooders and exhibit a high degree of

parental care. When fry of tilapias shoals or swim in schools, when attacked by predators they find or try to go to their mother (FAO, 2003). In natural surroundings where there are lots of opportunistic predators and risks everywhere, mothers would occasionally delay the discharge of her broods to protect them from being consumed (FAO, 2003). Meanwhile there are two methods of incubation applicable to this species which are artificial and natural incubation.

The use of artificial incubation units includes the elimination of ova and fry from the aperture of females and incubating them artificially as an active technique of tilapia fry production, but from research it is preferable to use natural incubation due to several reasons, these include the elimination of cannibalism, high production of even sized fry, increased spawning synchrony, shorten inter-spawning intervals. Sexual development starts at 150-180 days; Spawning begins at 24 degrees Celsius (El-Dakar *et al.*, 2004). Nile tilapia (*Oreochromis niloticus*) creates a zone and digs a nest, then the females deposit eggs in the nest. After insemination by the male, the female carries eggs in her mouth. The female nurtures the eggs in her mouth until hatching, about 7-14 days later. Subsequently fry are out, they may swim back into her mouth if endangered (FAO, 2006; 2007). Because of mouth brooding techniques, the number of eggs per spawn is smaller than other pond species, but survival rates of young are comparatively higher. Males can fertilize eggs from a succession of females, and if there is no drop in temperature females can spawn. Male species of *O. niloticus* grow twofold as fast, and sustaining a mono-sex population evades underdeveloped growth of individuals as a result of overpopulation. Pond culture, floating cage culture and

recirculation tank methods are also included in farming techniques (FAO, 2006, 2007). The most efficient and most affordable method is Genetically Modified Tilapia (GMT) with the use of Methyl testosterone to artificially form sex reversal. *Oreochromis niloticus* is an extensively cultured species because it grows and breeds in a wide range of ecological environments, in addition GMT is now the method well used in fish farm worldwide. All of the tilapia commonly grown for food fish are mouth-breeders. The main problem in tilapia culture is that females grow slower than males; early sexual maturation of females diverts energy from growth to reproduction, uncontrolled reproduction, overcrowding lead to stunt in tilapia growth making them unmarketable. Tilapias have a bisexual gonad (i.e., the pressure of ovarian and testicular tissues in gonad) in the male phase before they change to females (Mohamed *et al.*, 2007). All male populations are desirable, because males demonstrate superior growth characteristics compared to females. Moreover, culture of monosex populations prevents reproduction and results in a uniform size.

Tilapia is a generic term used to designate a group of commercially important fish species belonging to the family Cichlidae. Cichlidae family are classified into three aquaculture genera- *Oreochromis niloticus*, *Sarotherodon melanotheron* and *Oreochromis aureus*, they inhabit the fresh and brackish waters (Afunso *et al.*, 1999). Nile tilapia is preferred by farmers because of its desirable features for aquaculture i.e. tasty flesh and ease of production (Ayoola *et al.*, 2000). It has a faster growth rate compared with any other short cycled fish species including other commonly used tilapia strains. Moreover like other culturable tilapias, this species is a hardy

Growth and nutrient utilization parameters

The following indices were used to determine the biological evaluation of growth performance and nutrient consumed by the required fish.

Weight gain was determined between the final weight and initial weight of experimental fish.

Weight gain = Final weight - Initial weight

Specific Growth Rate

It is the percentage rate of change in the logarithmic body weight and was computed.

$$SGR = \frac{\log_{10} \text{final weight} - \log_{10} \text{initial weight}}{\text{Time (days)}}$$

Percentage Weight Gain

The % weight gain was determined as the difference between the final weight and initial weight of experiment fish

% weight gain =

$$\frac{\text{Final weight} - \text{Initial weight}}{\text{Initial weight}} \times 100$$

Feed Conversion Ratio

This was calculated using the formula

$$FCR = \frac{\text{Feed fed}}{\text{Fish weight gain}}$$

Protein Efficiency Ratio

It is calculated from the relationship between the increment in the weight of fish (i.e weight gain of fish) and protein consumed.

$$PER = \frac{\text{Mean weight gain (g)}}{\text{Protein intake}}$$

Protein Intake

PI = Feed intake × % of protein in diet

Percentage Weight Gain

$$\frac{\text{Mean weight gain}}{\text{Mean initial weight}} \times 100$$

Mean initial weight

Protein Efficiency Ratio (PER)

This was calculated from the relationship between the increments in the weight of fish and protein consumed.

$$\frac{\text{Mean weight gain (g)}}{\text{Protein intake}} \times 100$$

Protein intake (g)

Daily rate of growth (DRG)

This was calculated with the formula below:

$$DRG = \frac{\text{Mean increase in weight per day (g)}}{\text{Body weight of fish (g)}}$$

Daily rate of feeding (DRF)

This was calculated with the formula below:

$$DRF = \frac{\text{Mean ratio per day}}{\text{Body weight of fish}}$$

Gross Efficiency of Food Conversion (GEFC)

This was calculated with the formula;

$$GEFC = \frac{\text{Daily rate of growth}}{\text{Daily rate of feeding}}$$

Statistical analysis

Data were statistically analyzed using one-way analysis (ANOVA) of variance. Duncan's Multiple comparisons among means were made when significant F-values were observed ($P < 0.05$), using SPSS 18 statistical program.

Results

The results of water quality parameters showed that water temperature ranged from 26.8 - 30.5 °C with a mean of 25.85 ± 2.98 °C during the period of the experiment. The dissolved oxygen ranged between 3.3mg/l- 4.9mg/l with a mean of 4.16 ± 0.55 mg/l. The pH has a range of 7.11- 7.80 with a mean of 7.25 ± 0.31. The nitrate value ranged from 38.2mg/l to 42.5mg/l with a mean of 40.99 ± 1.38 and finally the nitrate value ranged from 7.9 to 8.4 with a mean of 9.44 ± 1.91. Ammonia value (X 0.01) range

fish. It is good converter of organic wastes in to quality protein and resistance to disease (Pullinet *al.*, 1988 and Lowe-McConnell, 1982). The production of a single sex population, especially of male, offers several advantages in tilapia aquaculture including enhanced growth and prevention of unwanted reproduction. There are various techniques that have been developed to provide male tilapia for culture which are manual sexing (Guerrero, 1982), hybridization (Hickling 1960), genetic manipulation (Pandian and Varadaraj, 1988) and hormonal sex reversal. (FAO,2012).The objectives of this study are to evaluate growth performance and culture potential of cultured *Oreochromis niloticus* in concrete pond and investigate the physical and chemical parameters necessary for rearing of *Oreochromis niloticus* (Nile tilapia) in concrete pond and the survival rate.

Materials and methods

Collection and acclimatization of fish samples

The study site was aquaculture unit of Department of Marine Sciences, University of Lagos. The aquaculture unit has five concrete ponds. A thousand species of Genetically Modified Tilapia, of *Oreochromis niloticus* were purchased from Durante fish farm, Ibadan, Nigeria and transported in oxygenated bags to aquaculture unit of the Department of Marine Sciences. The bags were lowered gradually into the concrete tank after acclimatization. Prior to this, the pond was thoroughly cleaned with fresh water. Physical and chemical parameters were taken once in two weeks. The water was changed once in two weeks to allow production of natural phytoplankton in the concrete pond such as *Scenedesmus* spp,

Microcystic spp, *Chroococcusturgidus*, *Euglena* spp, *Paramecium* spp, and mosquito larva.

Experimental set up

The concrete pond with a dimension of 1×1×5m was used for the experiment. The fish species were fed in the morning and evening daily with coppens at 3 percent of their body weight and the water parameters were taken once in two weeks. The mean weight gain of the specimen in the experimental set up was obtained at the end of every month.

Measurement of parameters

Weight measurement

The mean standard weight of the fish in the concrete pond was determined at the beginning of the experiment and at every two weeks. The weight of all the fish in the concrete pond was measured using a sensitive model and mean value was calculated.

Physical and chemical parameters measurement

Two samples bottles were dipped into the concrete pond during early morning hours. The first sample bottle was used to collect water sample for the determination of water temperature, dissolved oxygen and pH, while the water collected in the second bottle was used to determine ammonia concentration, Nitrite and Nitrate concentrations. Dissolved oxygen (DO), was measured using a dissolved oxygen meter, (Euteoti Do600 model), temperature was measured using mercury in glass thermometer and pH was determined using a pH meter (Lutron pH 241 model) respectively. The values of each parameter was monitored and recorded at 2 days intervals throughout the experimental period.

from 2 to 8 with an average value of $(4.4 \pm 0.01) \pm 2.4 \times 0.01$). Table 1 shows the value of physical and chemical parameters for duration of six months.

At the end of 6 months of feeding, the GMT males increased in size and growth. Table 2 shows the value of growth and nutrient utilization.

Discussion

The physical and chemical parameters monitored during the experiment include temperature, dissolved oxygen, ammonia ion, nitrate, nitrite, and hydrogen ion concentration (pH). Water quality conditions that will allow good growth and survival of fish include dissolved oxygen (DO) whose concentrations at optimal level of 5.0mg/l should ensure strong feeding

response. Optimum temperature is between 26°C–28°C. Temperatures below 24°C significantly reduce growth and may result in some fish not having completed gonadal differentiation during the treatment and may also encourage more diseases. These parameters have no negative effect on fish growth, since they fall within the range reported by Boyd (2004). It has been clearly shown from this experiment that all-male *Oreochromis niloticus* grew better in a concrete pond.

The feeding process involved during this experiment revealed that *Oreochromis niloticus* responded to imported feed (coppens 0.5mm-0.8mm) with crude protein of 56 percent given daily at the rate of 3 percent body weight. The mean weight gained (MWG) throughout the experiment

Table 1: Physico-chemical parameters taken in the concrete pond for 6 months (2013-2014)

PARAMETERS	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	MEAN±S.D
DO.	3.5	4.8	3.3	4.8	4.6	3.8	4.17±0.55
TEMP.(°C)	26.8	29.7	22.4	24.9	27.2	25.4	25.85±2.98
PH(MG/L)	7.41	7.32	7.11	6.9	7.3	7.11	7.25±0.31
NITRITE	9	10.2	8.8	8.0	10.1	7.9	9.44±1.91
NITRATE	41.6	38.2	40.9	39.6	42.9	41.0	40.99±1.38
AMMONIA	(×0.01) 6	5	4	2	8	2	4.4±2.4

Table 2: Growth and nutrient utilization of *Oreochromis niloticus*

PARAMETERS	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	MEAN±S.D
INITIAL MEAN WEIGHT (g)	3.5	5.9	9.6	13.73	14.5	17.5	10.78±5.40
FINAL MEAN WEIGHT (g)	4.0	7.6	11.8	15	16	18.64	12.17±5.51
MWG (g)	3.75	6.75	10.74	14.36	15.25	18.07	11.48±5.48
% MWG	405.25	227.9	143	105.55	99.5	84.25	177.6±122.9
DRF	170	200	205	210	218	225	204.6±19.2
WRF (kg)	1.19	1.4	1.44	1.50	1.53	1.58	1.44±0.14
MRF	5.1	6	6.15	6.3	6.54	6.75	6.14±0.57
FCR	1.36	0.88	0.57	0.43	0.42	0.37	0.67±0.38
SGR	2.07	3.9	3.2	1.3	1.5	9.7	0.002±0.001
GEFC	0.009	0.005	0.017	0.006	0.0068	0.005	0.006±0.002

increases from 3.75 to 18.07g, the data indicated that mean weight gained of *Oreochromis niloticus* increased gradually reaching its maximum of 18.07g at 25.4°C, the body weight gained by the fish increased gradually with temperature. Similar results were obtained by Saber *et al.* (2004). FCR values were 1.36 and 0.37g which gradually decreases throughout the experiment and also indicates that the lower the FCR the better it is. These results are in full agreement with the findings of Decroux *et al.*, (2004) and Saber *et al.* (2004). SGR was better and higher in values throughout the experiment.

The survival rates of tilapia during the experimental period were 100% at optimum temperatures; this is mainly due to the acclimation of tilapia prior to the start of stocking in the concrete pond this was in accordance to the finding of Saber *et al.*, (2004). The weather conditions throughout the experimental period were suitable for tilapia rearing with the temperature range from 20 to 30°C. Saber *et al.* (2004) noted that optimal water temperature for optimum growth and survival of tilapia was between 20-36°C. There was an increased trend towards the growth with an increase in dietary protein level.

Conclusion

The performance of fish culture depends on the quantity and quality of the feed as well as its effects on water quality and facility used in rearing the fish. Food availability and water quality appear to be the limiting factors for the growth of Nile tilapia (*Oreochromis niloticus*) (Kapetsky and Nath, 1997) in a concrete pond compare to earthen pond in which the productivity of the pond depends solely upon soil and water chemistry such as sunlight and temperature. To great extent water quality determines the

success or failure of a fish farming operation. The water temperature for the best performance of growth and survival rate of tilapia in the process of sex reversal is 30 °C. The fish were successfully reared in concrete pond and showed steady increase in weight throughout the experiment. Therefore evaluation of sex reversed Nile tilapia (*Oreochromis niloticus*) includes regular amount of feed inputs and concomitant responses to water quality variables. Use of GMT and protein levels would help to meet the goal of controlling tilapia reproduction with fast growth. In recommendation this result will definitely promote the use of genetically modify Tilapia in farming of Nile tilapia (*Oreochromis niloticus*) as more weight, length and hence growth is more achieved in a lesser time.

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